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ABSTRACT

Samples taken from various operations at two recycle newsprint mills show that stickies agglomerate into mixtures either at, or just after, the repulper. The proportion of a mixture of polyvinyl acetate (a hot melt) and acrylate (a pressure-sensitive adhesive) increases progressively, and predominates in the final accepts. Hence, this mixture is concluded to be the most difficult stickie to remove in newsprint mills. The specific gravity of the stickies in the final accepts was much more temperature-sensitive than was that of water, which suggested a new cleaning strategy. Introducing a small temperature difference between two sets of cleaners should enhance cleaning efficiency, since a contaminant of specific gravity of unity in one cleaner must have a different specific gravity in the other.

INTRODUCTION

Most of the stickies that enter a mill are removed through screening and cleaning, and it is only a very small subset that is found in the final accepts. Since these are the problem stickies, we conducted a study to determine whether they had a signature or characteristic that enabled them to traverse the cleaning system. Accordingly, we sampled pulp at various unit operations at Bowater's East Millinocket, ME, mill, and at Augusta Newsprint's facility in Augusta, GA, and analyzed the various contaminants by infrared spectroscopy. Our objective was to determine the type and distribution of contaminants found at various stages of processing. The results provide insight into some of the factors that influence the cleanability of stickies, and suggest strategies that should enhance the efficiency of contaminant removal in centrifugal cleaners, without incurring major capital expenditure.

EXPERIMENTAL

Augusta Newsprint

The furnish used consisted of a 4:1 mix of old newsprint (ONP) and old magazine (OMG). The newsprint and magazine are pulped separately in a batch process and placed in separate dump chests. The two pulps are then sent through high-density cleaners separately before being blended together, and passed through a set of coarse screens. The stock then moves sequentially through four Beloit flotation pressurized deinking modules (PDM's), a primary and secondary set of reverse cleaners, a disk filter, and a screw press. It is then "acid-shocked" from a pH of approximately 9.5 on the alkaline side to a value of approximately 5, and is sent through the forward cleaners, slotted fine screens, an acid disk filter, and then on to the recycled high density chest. The pulp is diluted with paper machine water at a pH of 6.5 in a low-density chest and sent to the paper machine blend chest. Approximately 40% of the fiber used was recycled pulp, 52% was thermal mechanical pulp, 7% was virgin, and 1% was broke.

Samples were collected on three occasions. On the alkaline side of the process, samples were taken from the magazine dump chest, recycle blend chest, coarse screen accepts, and reverse cleaner feed and accepts. On the acid side, samples were drawn from the forward cleaner feed and accepts, and the fine screen accepts. The machine chest of the paper machine was also sampled. After the first sampling, the slots of the fine screens were reduced from 0.008 inches to 0.006 inches. The turbidity of the white water system also decreased by about 50%, probably because of a change in the type and amount of surfactant used. Additional details are provided in reference (1).

Great Northern Paper recycle mill

Great Northern Newsprint (GNP) produces 450 tons per day of 100% recycled deinked pulp from a furnish consisting of 75% ONP and 25% OMG. The ONP was approximately 60% overissue, 20% flexographic ink, and 20% sorted Number 8. The stock preparation line consists of an alkaline loop and an acid loop for deinking, contaminant removal, and bleaching. Each loop has separate white water circuits and clarification. The alkaline loop consists of coarse and fine screens, multiple pressurized flotation cells, forward cleaners, thickener/washers and dispersion. The acid loop includes pressurized flotation cells, forward and through cleaners, and thickener/washers prior to being diluted with paper mill white water to the desired consistency and pH for high-density storage.

The ONP and OMG are stored separately, and the incoming bales are pulped in a high-consistency, low- temperature continuous drum pulping operation. Unclarified water from the alkaline gray water chest is cyclically treated with biocide prior to being used for pulping. The pulper pH is maintained at a control pH of 9.4 through the addition of sodium hydroxide. The low pulping temperature (approximately 115°F) and moderate shear is intended to prevent the breakdown of contaminants, keeping them large enough to be removed by physical methods. The alkaline pH promotes fiber swelling and flexibility, which enhances ink detachment. High pulping consistency improves ink detachment through increased fiber-to-fiber contact.

The pulp is fed at 2.5% consistency to the pulper dump chest, followed by a high-density cleaner and an alkaline swelling chest. Contaminants are then removed through 0.050-inch coarse screens, followed by 0.006-inch slotted fine screens. After the first collection, the 0.006-inch slotted fine screens were replaced by 0.004-inch wedge slotted fine screens. The wedge slots allow for a large increase in pass through area (more slots per inch), and a lower passing velocity. Pressurized deinking flotation cells follow the screens. Forward cleaners are then employed for "heavy" contaminant removal. The pulp is then washed in a double nip thickener, followed by a screw press. A refiner used for dispersion completes the alkaline loop. The stock is subsequently diluted with acid and acid loop whitewater and then sent to flotation cells. Cleaning is accomplished through forward and through hydrocyclones arranged in series. Again the stock is washed with double nip thickener washers and screw-pressed. The pulp is finally diluted with paper mill white water for high-density storage. On the alkaline side, samples were taken from the coarse and fine screen accepts; on the acid side, the forward and through cleaner accepts, and the double nip thickener accepts were sampled. Additional details regarding work at GNP is provided in reference (2).

Determination of stickies

Samples taken from specific points in the mill were either directly poured onto filter paper, or run through a Pulmac Masterscreen with 0.004 inch (100μ) slots. The isolated contaminants were then tested with a pointer to determine whether or not they were tacky, and these were the only contaminants determined to be stickies. They were then removed from the filter paper, separated from the attached fibers, and analyzed by FTIR spectroscopy. For the GNP samples, image analysis image was used to obtain specific stickies counts and area (2). The stickies were usually larger than 100 μ. The spectra were analyzed by the "Dewiggle" algorithm (3,4) that deconvolutes a spectrum of mixtures into its components. The procedure is based on the fact that if a spectrum is overlaid on another spectrum, a more complex spectrum containing more "wiggles" results. Conversely, if a known spectrum is exactly removed from a spectrum of a mixture, the number of "wiggles" should decrease. Different fractions of a library spectrum are subtracted from the unknown, and a measure of the number of wiggles taken at each point. If the number minimizes, which will occur at the point of exact subtraction, then the library spectrum is identified as being part of the unknown at a fraction equal to that used at the point of exact subtraction. The routine is fully automated, and has been commercialized by Galactic Industries (5).

Buoyancy measurements

Individual stickies removed from the Pulmac screen at Augusta Newsprint were placed in 50°F water, whereupon they sank, indicating that their specific gravity (ρ) exceeded one. The temperature was then raised gradually at 0.5°F per minute with occasional stirring. When the stickie began to float, the bath was again stirred to prevent the air released from solution from assisting stickie flotation.

DISCUSSION

The qualitative composition of stickies identified at various points in the two mills studied is provided in Tables 1 and 2. First, note that the stickies are usually present as mixtures, a finding consistent with previous work (6,7). Yet, when stickies associated with the incoming furnish were analyzed directly, they were almost always found to be pure. Hence, reagglomeration either occurs at, or shortly after, the repulper.

The stickies found at the front end (Tables 1 and 2) reflect the usual spectrum of materials used in the business. Interestingly, the relative abundance of the mixture of polyvinyl acetate (PVAc) and acrylate (ACRY) increases as we move down the process. In other words, although the total number of contaminants decreases substantially, the <u>proportion</u> of this particular mixture increases in the few stickies that remain. For the two collections at Augusta, only 22% and 9% of the stickies, respectively, in the alkaline magazine dump chest are PVAc/ACRY mixtures (Table 1), whereas this mixture represents 44% and 50%, respectively, of the stickies in the acid fine screens accepts. At GNP, the corresponding values are 40% and 50% at the coarse screen accepts, and 71% and 51% at the DNT. Hence, we conclude that this mixture is much more difficult to remove than the other stickies. Given that the Augusta Newsprint and the GNP mills are of different configuration, and obtain their fiber from different sources, the similarity of their stickies profiles in Tables 1 and 2 suggest that the recalcitrance of the PVAc/ACRY mixture may be universal, and may apply to other newsprint mills.

The Augusta mill reduced the size of their fine screen slots from 0.008-inch to 0.006-inch between the first and the second collection. However, this did not affect the proportion of the PVAc/ACRY mixture in the fine screen accepts, indicating that this mixture is deformable enough to traverse the screens. GNP also replaced their 0.006-inch slotted fine screens with 0.004-inch wedge slotted screens between the first and second samplings. The wedge slots allow for a large increase in pass-through area (more slots per inch) and a lower passing velocity. Although the upgrade reduced the stickies count of the fine screen accepts as illustrated in Table 3, the PVAc/ACRY mixture still predominated in the DNT accepts. Clearly, this mixture is both ubiquitous and resilient.

In order to compare the buoyancy of the stickies at the front and back ends, transition temperatures were measured for stickies taken on two occasions from the repulper and the fine screen accepts at Augusta Newsprint. The results, shown in Table 4, suggest that the transition temperatures are higher at the fine screens. At this temperature, a stickie should have a specific gravity of one, and, in principle, should be completely transparent to the cleaners. The Table 4 values are lower, possibly because cleaner efficiency is governed not only by the specific gravity of a contaminant, but also by its size and shape (8).

Importantly, the transition temperatures in Table 4 were quite sharp at between 1-2°F. When the water was cooled, the stickie sank at the same transition temperature, again within 1-2°F. The coefficient of thermal expansion of a stickie is generally higher than that of water; for PVAc the difference is a factor of three at 20°C (9). This suggests that if forward and reverse cleaners are run at different temperatures, then a stickie that has a specific gravity of one in the first cleaner cannot have a specific gravity of one in the other. Hence, maximizing the specific gravity difference between stickies and water should be key to optimal stickie removal (10).

The two most practical ways of introducing a temperature difference between cleaners is to either situate them across a high-energy operation such as fine screening, or to simply inject waste steam in between the cleaners. GNP estimates the incremental cost of 40# steam to be $1.75/ MMBTU or about $1.75/1,000 lbs. of steam (11). For a 450 tpd mill (1% consistency, 5,000 gpm stock to cleaners) this equates to about $0.01/ton/°C, which is very affordable. Pilot trials are being planned.

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Table 1: Contaminant profiles at Augusta Newsprint

	first collection	second collection
alkaline magazine dump chest	PVAc, EVA, GWD, clay, SURF, 2 PVAc/ACRY, PVAC/SBR, EVA/clay	EVA, ACRY, PVAc/ACRY, PVAc/SBR, 2 EVA/resin, 2 EVA/ACRY, ACRY/styrene, ECVA/ACRY/clay, EVA/resin/ DEF
alkaline blend chest	defoamer, 2 PVAc/ACRY, 2 EVA	
alkaline coarse screen accepts	2PVAc, 4 PVAc/ACRY, 2 polyethylene/wax	
alkaline reverse cleaner accepts	3 PVAc, 2 SURF, pigment, EVA, PVAc/clay	ACRY, 2 PVAc/ACRY
forward cleaner feed	3 EVA, 2 PVAc, ACRY, ACRY/polypropylene, ACRY/SURF	
forward cleaner accepts		4 PVAc, 5 PVAc/ACRY, 2 EVA/ACRY
acid fine screen accepts	pitch, extract, PVAc, ACRY, 4 PVAc/ACRY, EVA/ACRY	asphalt, 5 PVAc/ACRY, 2 ACRY/clay, ACRY/EVA, ACRY/plast

PVAc: polyvinyl acetate; EVA: ethylene vinyl acetate; GWD: groundwood; SURF: surfactant; ACRY: acrylate; SBR: styrene butadiene rubber; DEF: defoamer; extract: extractives; plast: plasticizer

Table 2: Contaminant profiles at Great Northern Paper		
	first collection	**second collection**
alkaline coarse screen accepts	DEF/wax, SURF/polyisoprene, 2 PVAc/ACRY, DEF/SBR/EVA	ACRY, pitch, extract, resin, 3 PVAc/ACRY, disp/PVAc, plast/PVAc/ACRY, plastic/PVAc
alkaline fine screen accepts	ACRY/DEF, SURF/coating, 2ACRY/surfactant, coat-ing/SURF	ACRY, SBR, SURF, pitch, SBR/disp, clay/disp, 2PVAc/ACRY, extract/DEF, ex-trac/ACRY, EVA/SBR, ACRY/PVAc/clay, PVAc/SBR
acid forward cleaner accepts	PVAc, 2ACRY, DEF, ACRY/extract, PVAc/DEF, PVAc/ACRY, clay/SURF, SURF/PVAc/ACRY, DEF/SBR	
acid through cleaner accepts	ACRY, DEF/ACRY, ACRY/EVA, PVAc/ACRY, DEF/clay, EVA/ACRY, poly-isoprene/DEF	talc, 9 PVAc/ACRY, EVA/SBR, ACRY/PVAc/clay
acid double nip thickener accepts	ACRY, 5 PVAc/ACRY, PVAc/SBR	DEF, 2 extract, wax/SURF, ACRY/extract, 7 PVAc/ACRY
disp: dispersant		

Table 3: Effect of a fine screen upgrade at GNP on stickies count				
	first collection		second collection	
	count/o.d.g. stock	mm^2/o.d.g. stock	count	area (mm^2)
alkaline coarse screen accepts	0.80	0.172	0.80	0.166
alkaline fine screen accepts	0.52	0.044	0.32	0.029
alkaline PDM accepts	0.25	0.012	0.05	0.001
acid forward cleaner accepts	0.33	0.016		
acid through cleaner accepts	0.35	0.057	0.20	0.075
acid DNT accepts	0.60	0.066	0.28	0.025

Table 4: Transition temperatures (°F) of stickies			
	process temp	avg. transition temp (av dev)	n
first collection			
dump chest	119	99 (4)	5
fine screen accepts	124	109 (8)	5
second collection			
dump chest	119	93 (2)	7
fine screen accepts	126	100 (5)	9